

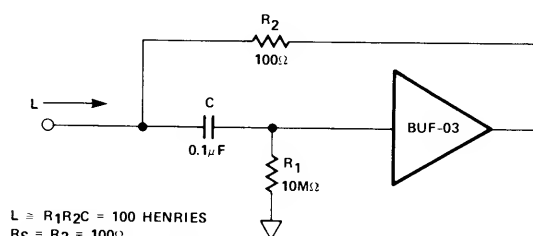
## A Buffer Amplifier Applications Collection

### INTRODUCTION

This Application Note consists of a collection of circuits which use buffer amplifiers in a variety of applications. As will be shown, buffers may be used to make filters, current sources, cable drivers, sample and holds, line drivers for multiplexers, current boosters, and high speed voltage output DACs.

### INDUCTORS AND FILTERS

The active inductor in Figure 1 is realized with an eight-lead IC, two carbon resistors, and a small capacitor. A commercial inductor of 50 henries may occupy up to five cubic inches.



$$L \approx R_1 R_2 C = 100 \text{ HENRIES}$$

$$R_S = R_2 = 100 \Omega$$

$$R_P = R_1 = 10 \text{ M}\Omega$$

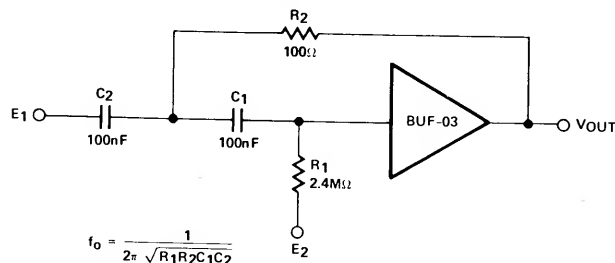
ASSUMING  $C_{\text{STRAY}}$  (ACROSS  $R_1$ ) OF 5pF THE UPPER FREQUENCY LIMIT IS APPROXIMATELY 7kHz.

$$X_L = 100 \Omega \text{ AT } f = 0.159 \text{ Hz}$$

OUTPUT CURRENT SHOULD BE LIMITED TO A MAXIMUM OF 50mA.

**Figure 1. Active Inductor**

The tuned circuit shown in Figure 2 uses the simulated inductor of Figure 1 ( $R_1$ ,  $R_2$ ,  $C_1$ ) and  $C_2$ . Depending upon whether the circuit is driven at  $E_1$  or  $E_2$  the responses of Figures 3 or 4 result. The resonant response in both cases is

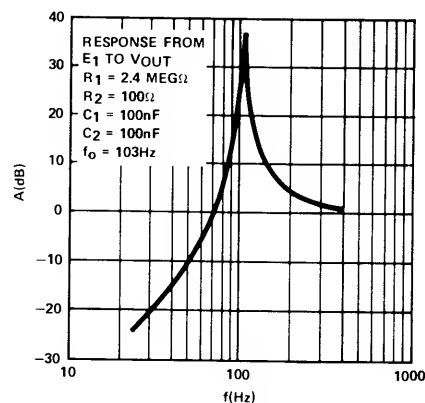


$$f_o = \frac{1}{2\pi \sqrt{R_1 R_2 C_1 C_2}}$$

INPUTS MAY BE AT  $E_1$  OR  $E_2$ . GRAPHS OF THE TWO RESPONSES WILL SHOW ADVANTAGES AND DISADVANTAGES.

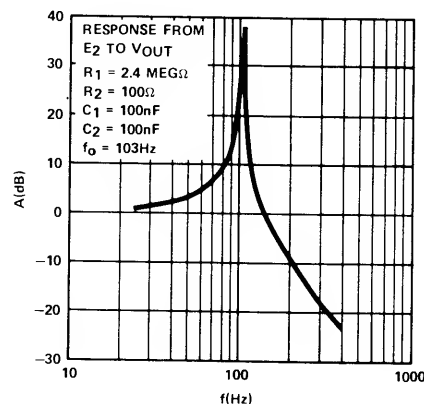
**Figure 2. Tuned Circuit**

+38dB at 103Hz. The Figure 3 response is +2.5dB at 200Hz and -10dB at 50Hz. On the other hand, the Figure 4 response is -9dB at 200Hz and +2.5dB at 50Hz.



$$\frac{V_{OUT}}{E_1} = \frac{-\omega^2 R_1 R_2 C_1 C_2}{1 - \omega^2 R_1 R_2 C_1 C_2 + j\omega R_2 C_1 \left(1 + \frac{C_2}{C_1}\right)}$$

**Figure 3. Response from  $E_1$  to  $V_{OUT}$**



$$\frac{V_{OUT}}{E_2} = \frac{1 + j\omega R_2 C_1 \left(1 + \frac{C_2}{C_1}\right)}{1 - \omega^2 R_1 R_2 C_1 C_2 + j\omega R_2 C_1 \left(1 + \frac{C_2}{C_1}\right)}$$

**Figure 4. Response from  $E_2$  to  $V_{OUT}$**

Figure 5 shows a low pass filter realized for  $f_o$  of 1MHz. What is remarkable about this filter is most ICs do not have the full power bandwidth to handle 1MHz signals in the 5 to 10 Volt range, while the BUF-03 has a greater than 4MHz full power bandwidth for a 20V<sub>p-p</sub> sinewave. Similar comments apply to the filter in Figure 6. In other words, the outstanding bandwidth of the BUF-03 extends the bandwidth capability of certain classes of active filters.

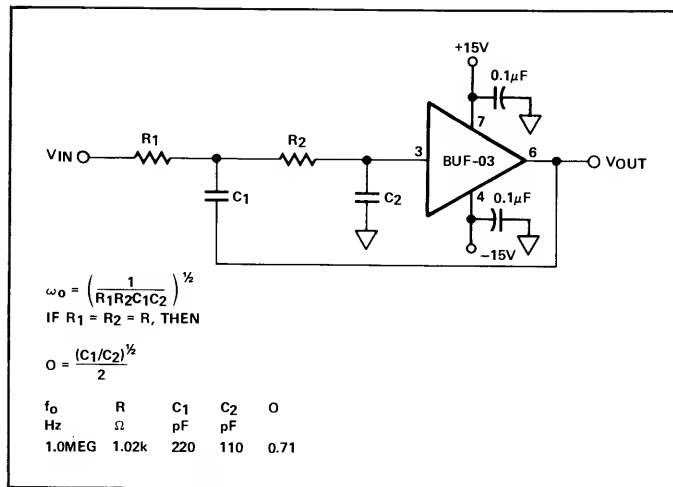


Figure 5. Low Pass Filter (High Frequency)

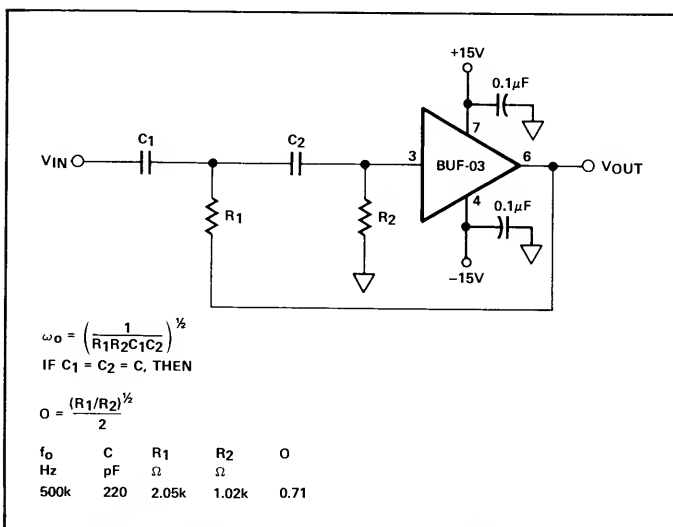


Figure 6. High Pass Filter (High Frequency)

The BUF-03 can be used to make a 4.5MHz trap for use in TV. This circuit is shown in Figure 7, and the elements are chosen such that no capacitor is less than 100pF.

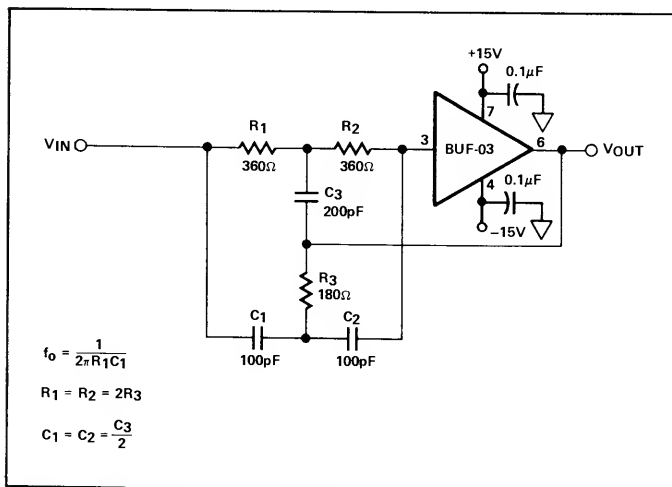


Figure 7. Notch Filter at 4.5MHz

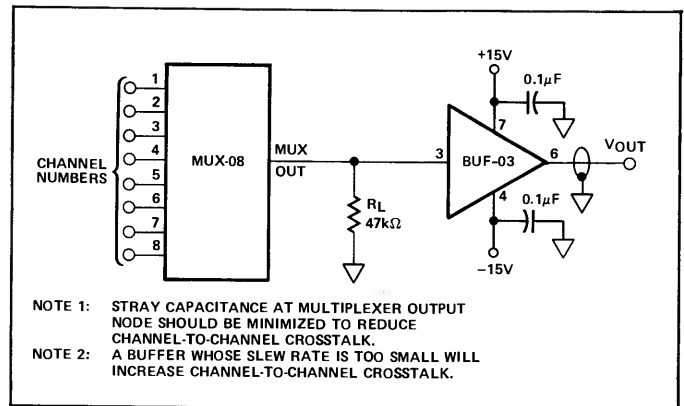


Figure 8. High Speed Line Driver for Multiplexers

The BUF-03 can be used as a data line driver because of its speed and current drive capabilities. The connection for this application is shown in Figure 8. The realization of a high speed sample and hold is possible using the BUF-03 and suitable analog switches. The circuit shown in Figure 9 provides the highest speed because there are no feedback loops to slow down the settling times. Typically the sample and hold is followed by a successive approximation analog-to-digital converter (ADC). The final application involves the BUF-03 and the DAC-08 (digital-to-analog converter). Figure 10 shows how it is possible to develop both  $V_{OUT}$  and  $\bar{V}_{OUT}$ . The output capacitance of the DAC-08 is approximately 15pF, thus as  $R_0$  increases in value, so does the settling time for  $V_{OUT}$  (and  $\bar{V}_{OUT}$ ).

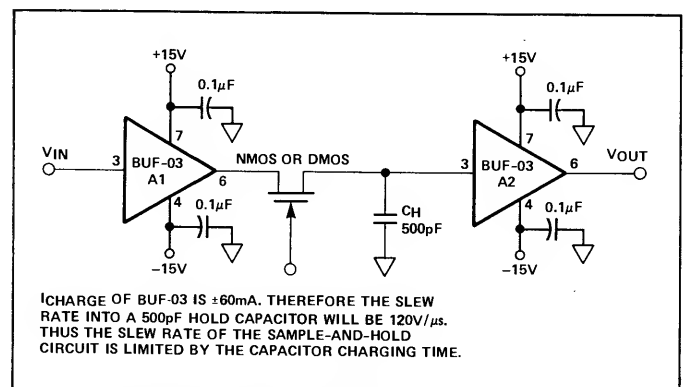


Figure 9. High Speed Sample and Hold

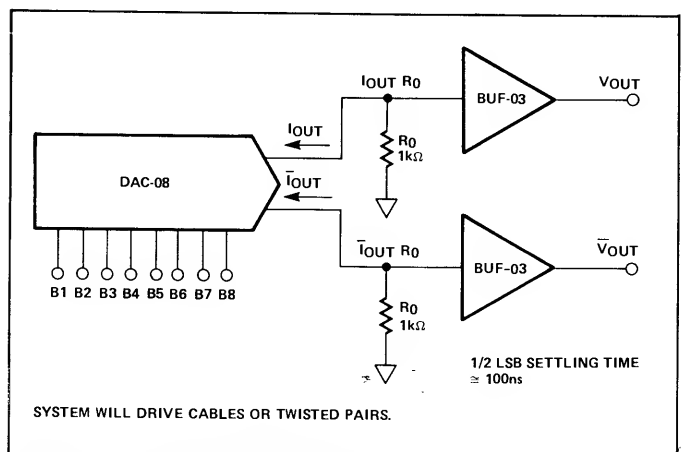


Figure 10. High Speed Voltage Output DAC

## LINE DRIVER APPLICATIONS

If your FET "line driver" has the speed but not the stability or the current capability to drive coaxial cables, its output may be buffered with a BUF-03 as shown in Figure 11. Figure 12 shows an alternative connection when better accuracy and high current capability is needed. Note that the limitation on  $R_L$  being greater than  $1k\Omega$  does not apply in this case since the added error caused by lower impedances is imbedded inside the feedback loop of the op amp.

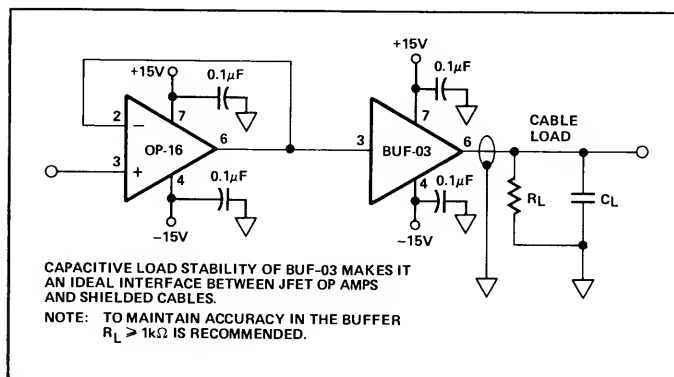


Figure 11. Convert FET Op Amp Into Cable Driver

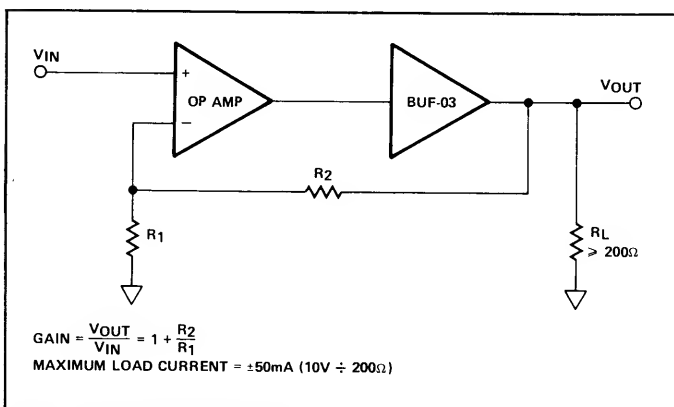


Figure 12. Current Booster

## MISCELLANEOUS USES OF BUFFERS

Single supply applications can be realized using the BUF-03 as shown in Figure 13. The input is DC biased to +10V such that the BUF-03 operates in the linear region. Signal is AC coupled to the input and also AC coupled to the output load resistor.

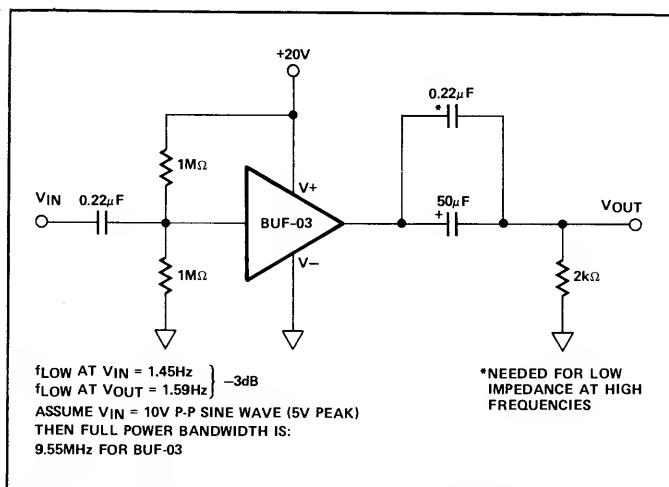


Figure 13. Single Supply AC Buffer (High Speed)

## CONCLUSION

While the list is by no means all inclusive, this application note has attempted to point out some of the myriad of uses for the IC buffer. In particular, the BUF-03 makes possible a whole new class of high frequency filters and high speed current sources. Many problems in data acquisition systems can be solved by the use of buffers. In addition, the BUF-03 is useful in providing increased drive current, as well as the ability to drive long cables without instability. Finally, the versatility of the reference zener can be increased by using buffers, and for AC applications the buffer can be used on single power supplies.